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Convective Circulations in the Atmosphere

By D. BRUNT, M.A.

AN interesting phenomenon relating to the stability of horizontal layers of fluid can be demonstrated by pouring a small amount of cheap gold paint into a metal ash-tray, filling it to a depth of two or three millimetres. The cheaper varieties of gold paint contain a certain amount of benzene or other volatile constituent, which evaporates vigorously from the surface, producing a cooling of the surface layer, and therefore yielding an unstable state. When the fluid is first poured into the tray, we notice the existence of a very large number of centres at which vigorous ascent of fluid takes place. In a few seconds the number diminishes, leaving the fluid divided into polygonal prismatic cells, each of four to seven sides. The diameter of the polygons is about three times the depth of the fluid. There will be a number of smaller cells which will be squeezed out of existence by the larger cells, and after about half a minute the structure will have settled down to a relatively permanent form.

If attention is concentrated on a single polygonal cell it will be noted that there is vigorous ascent in the central region, and descent at the outer edges, with outflow in between. The return inward current is in the bottom layers of the fluid. The small solid particles (presumably bronze) can be seen to be in rapid motion within each separate cell, but there is a small region in the centre of each cell which is clear of solid particles,

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and around the periphery there is a narrow belt of clear fluid.

The cell circulation continues so long as there is evaporation from the surface, but the circulation can be stopped by covering the tray with a piece of glass. When the glass cover is removed the evaporation recommences, and the polygonal structure again becomes distinct. The pattern can at any time be destroyed by shaking the tray. If the tray is tilted it will be noted that the cells are larger in the deeper fluid, and diminish in size towards the shallow edge. By adjustment of the amount of fluid in the tray it is possible to show, not only that the polygons increase in size with increasing depth of fluid, but also that on the shallow side the structure abruptly terminates with cells of a finite size, leaving a shallow layer of fluid which is clear of cellular structure. In the course of a few minutes most of the solid particles will have been deposited on the bottom of the tray, and if the tray be very quietly shaken it will be found that the polygonal cells which form in the now shallower layer of fluid will be smaller than before.*

The phenomenon described above was first described by W. H. Weber in Poggendorf's *Annalen*,† the cellular structure being observed in a layer of alcohol and water on a microscope slide. It was also described by James Thomson in a paper entitled "On a Changing Tesselated Structure in Certain Liquids."‡ Thomson observed a similar structure in layers of soapy water, 4 or 5 inches deep, cooled from the surface. The same phenomenon has been observed in widely different fluids by Frankenheim and Bénard. The investigations of Bénard were carried out with very carefully adjusted apparatus, and yielded some very striking results. In some of Bénard's photographs, the individual cells are shown as perfect hexagons. Bénard generally worked with layers of fluid of about 1 mm. in depth, and he used a variety of liquids, in each case maintaining a known difference of temperature between the top and bottom of the layer. Bénard's experiments and results are fully described in "Les Tourbillons Cellulaires dans une Nappe Liquide," a thesis for the degree of Doctor, published by Gauthier-Villars, 1901. Bénard also found that if the fluid had a general flow in one direction when instability was first set up, the cells were drawn out into long strips, parallel to the direction of flow. This phenomenon can be obtained roughly with gold paint by moving the tray to and fro.

* The reader who is interested in this experiment is strongly advised to try it for himself. The total cost of a bottle of gold paint and a tray will not exceed 7d. There is a commercial preparation called "Avenue Liquid Gold," whose use was recommended by Mr. Gibson, Air Ministry, which gives excellent results. A small tray such as is used for baking mince-pies can be used for the experiment.

† *Annalen d. Physik u. Chemie. Bd.* XCIV, 1855, *p.* 452.

‡ Glasgow, Proc. Phil. Soc., 1881-2.

The underlying physical processes were discussed by the late Lord Rayleigh in a paper "On Convection Currents in a Horizontal Layer of Fluid, when the Higher Temperature is on the Under Side."* Rayleigh based his discussion on the consideration that when a system falls away from unstable equilibrium, it may do so in several principal modes, in each of which the departure at time t is proportional to the small displacement of velocity supposed to be present initially, and to an exponential factor e^{qt} where q is positive. If the initial disturbances are small enough, that mode (or modes) of falling away will become predominant for which q is a maximum. Rayleigh's main results may be briefly stated as follows :—

(1) If ρ_1, ρ_2 be the densities of the fluid at the bottom and top of the layer whose thickness is h, stable equilibrium is possible with the denser fluid above, so long as :—

$$\frac{\rho_2 - \rho_1}{\rho_1} < \frac{27\pi^4 \kappa\nu}{h^3}$$

where κ is the coefficient of thermal conduction, and ν the coefficient of viscosity.

(2) When the cellular circulation is set up, if the separate cells are squares, the side of the square is $2\sqrt{2}$ h.

(3) For hexagonal cells, the diameter of the circle inscribed in the hexagon is a little greater than $3\frac{1}{2}$ h.

(4) For fluid with a general flow, the width of the strips is twice the depth of the fluid.

Rayleigh's discussion thus affords a complete explanation of the results derived with gold paint as described above, viz.: when the dish is tilted, the cells are bigger in the deeper fluid and there is a shallow layer in which no cells are formed. The meaning of the formula given in (1) above is that in a fluid which has a finite conduction of heat, and a finite coefficient of viscosity, the effect of conduction in wiping out local deviations of temperature and of viscosity in damping out small velocities, is to maintain stability under conditions which would otherwise be regarded as unstable.

Rayleigh's discussion applies only to incompressible fluid and is therefore not directly applicable to air, but it at once suggests by analogy an explanation of the occurrence of superadiabatic lapse rates in the atmosphere. Rayleigh shows that, neglecting compressibility, a difference of 9° C. is consistent with stability in a layer of air 1 cm. in thickness. It follows that in a layer of air 1 metre in thickness, the difference of temperature (neglecting compressibility) which could exist, would be a very small fraction of a degree. Now, it is known that in air the transfer of heat by molecular conduction is in practice negligible by comparison with the transfer of heat by radiation and absorption,

* *Phil Mag. Vol.* XXXII, *Dec.*, 1916, *p.* 529.

and it is suggested that in Rayleigh's inequality in (I), above, the coefficient of conduction κ should be replaced by a much larger coefficient to represent the effect of absorption and radiation. I am at present endeavouring to obtain a similar inequality for compressible fluid, allowing for absorption, but for the moment we shall have to be satisfied with using the analogy suggested by Rayleigh's result. This analogy is very attractive, since it appears to explain the fact that a considerable degree of nominal instability can be built up in the atmosphere. The existence of very large lapse-rates is at times denoted by the formation of mirages. As another example we may cite the case of thunderstorms, which are preceded by a vertical distribution of temperature corresponding to a mean lapse rate largely in excess of the adiabatic, the thunderstorm forming with great suddenness, suggesting that the lapse rate attains a critical value beyond which equilibrium is impossible.

But, apart from the question of the physical process of formation of apparently unstable vertical distributions, the form of falling away from unstable equilibrium discussed by Rayleigh and others, and illustrated by the experiment with gold paint described above, is of frequent occurrence in meteorological phenomena. An obvious case is that of mammato cumulus clouds, in which the instability is probably due to the descent of cloud, with a layer of clear air beneath. The clear air is warmed at the dry adiabatic rate, while the cloud is warmed at the wet adiabatic rate, and so leads to instability, and the breakdown of the unstable condition in a number of small cells is very well illustrated in typical photographs of mammato cumulus cloud. The explanation of the structure of the mammato cumulus cloud here offered would require that the instability should be restricted to a relatively thin layer. Photographs of alto cumulus also show a similar structure. Other varieties of cloud which show small globular structure may possibly be ascribed to the same process. The gradation of size of the globules frequently noticed in high clouds would then be ascribed to a gradation of thickness of the layer through which instability occurs.

In the observations of Bénard and others, the lower boundary of the layer of fluid is a solid layer, and the motion is upward at the centre of each cell. In the case of an unstable layer in the atmosphere at some height above the ground, the bounding surfaces are both interfluid surfaces, and there is no obvious criterion for determining whether the motion should be upward or downward at the centre of each cell. It is worthy of note that an unstable condition may be produced in the atmosphere by the descent of a layer of dry air with a layer of cloud above it, or by the ascent of a layer of dry air with a layer of cloud below it. In either case, if the instability is restricted to a shallow

layer, the breakdown of equilibrium will take the cellular form, and any resulting cloud will be of a flocculent form.

There are probably many other meteorological phenomena which are capable of explanation by the same cellular mechanism. The examples cited above suffice to show that the principle is one capable of application to widely different fluids, and therefore merits the attention of meteorologists.

Discussions at the Meteorological Office

January 19th, 1925. *Étude sur les microséismes* (*Observatoire de Zi-ka-wei*, 1924). By R. P. E. Gherzi, S.J. (Zi-ka-wei—Changhai). *Opener*—Capt. H. W. L. Absalom.

It is a remarkable feature of seismographic records that they show the earth to be subject to continual tremors obviously different from earthquakes in character as well as in magnitude. It was suggested long ago that these tremors or microseisms might be due to waves beating on distant coasts, or that they were associated in some other way with the weather. By his study of the records of the Zi-ka-wei Observatory, Father Gherzi has been led to the further conclusion that microseismic disturbances may be grouped into various classes: (1) those due to cyclones, (2) those due to anticyclones, (3) those due to cold, and (4) those due to other causes. Each of the three definite classes has its own type of microseismic record. It remains to be seen whether similar associations are to be traced in other parts of the world. If they can, it will be clear that the mechanism of microseismic activity is primarily meteorological.

February 2nd, 1925. *La prévision scientifique du temps.* By G. Guilbert (Paris, 1922). *Opener*—Mr. G. R. Hay.

The name of M. Gabriel Guilbert has been familiar to English meteorologists since he won the international forecasting competition at Liège in 1905, and it was announced that his success was due to his use of a certain set of empirical rules. During and since the War, M. Guilbert has elaborated his system by incorporating some of the rules based on the movement of clouds to which so much importance is attached by French meteorologists of the Delcambre school. In the work under discussion, the author defends his claims with much vigour. His dicta are, however, so frequently at variance with accepted ideas that he cannot hope to gain the confidence of more conventional meteorologists. If the formation of cloud and the production of rain are not associated with the ascent of air, our faith is indeed vain. It came out in the discussion that it was largely due to the

publication of M. Guilbert's rules, which turn on the relation of wind to pressure gradient, that the notion of the "gradient-wind," was introduced into English meteorology. If on that account alone he is entitled to our gratitude.

The subjects for discussion for the two meetings in March, will be :—

March 2nd, 1925. *Wellen und Wirbel an einer quasistationären Grenzfläche über Europa.* By T. Bergeron and G. Swoboda. (Veröff Geophys. Inst., Leipzig, 2 Ser., Bd. III., H. 2). *Opener*—Major A. H. R. Goldie.

March 16th, 1925. *Diagnostic and prognostic application of mountain observations.* By J. Bjerknes. (Geofys. Pub., Christiania, Vol. III., No. 6). *Opener*—Mr. F. J. W. Whipple.

Royal Meteorological Society

THE Annual General Meeting of this Society was held on Wednesday, January 21st, at 49, Cromwell Road, South Kensington, Capt. C. J. P. Cave, M.A., President, in the Chair. The Report of the Council for 1924 was read and adopted, and the Council for 1925 duly elected.

At the ordinary meeting which immediately preceded the Annual General Meeting, vacancies in the list of Honorary Members of the Society were filled by the election of the following distinguished foreign meteorologists :—

Dr. C. G. Abbot, Director, Mount Wilson Observatory.

Dr. W. van Bemmelen.

Dr. E. van Everdingen, Director, Netherlands Meteorological Service; President, International Meteorological Committee.

Dr. F. Exner, Director, Austrian Meteorological Service.

Prof T. Okada, Director, Central Meteorological Observatory, Tokio.

Dr. A. Wallén, Director, Swedish Meteorological Service.

A year ago the establishment of the Buchan Prize to commemorate the incorporation of the Scottish Meteorological Society with the Royal Meteorological Society was announced. The first award of the prize is to Mr. W. H. Dines. It is given for papers, principally on radiation, published recently in the *Quarterly Journal.* Mr. W. H. Dines was debarred by the state of his health from attending the meeting, and the certificate of the award was handed by the President to Mr. J. S. Dines on behalf of his father. Mr. W. H. Dines has been a pioneer in several branches of meteorology. His name is familiar to all meteorologists in connection with anemometry and with upper air research. It may well be that his work on radiation will be equally far-reaching. It was interesting to learn that Mr. Dines

was in touch with Dr. Buchan when the equipment of the Ben Nevis Observatory was under discussion, and also that Mr. Dines, as President of the Society, had given the first Symons Medal to Dr. Buchan.

In his Presidential Address, Mr. Cave covered a wide range. He laid most stress on the need for more general meteorological education. He urged that the best way to convince the public of the possibilities of modern forecasting was the prompt circulation of forecasts, and asked for the broadcasting of forecasts, not only in the evening but also in the morning and early afternoon.

Correspondence

To the Editor, *The Meteorological Magazine*

A Roof for the Campbell-Stokes Sunshine Recorder

In connection with Capt. Johnson's* letter and illustrations of the means adopted for protecting the sunshine recorder from hoar frost, perhaps your readers may be interested in the method that has been adopted here since 1921. After sunset or even later (at the 21 h. observation) when frost seems likely to occur, a cup or "hood" made of chamois leather and drawn with elastic at the opening is placed over the lens and fits snugly over the entire bowl as well. As additional protection a thick, brown paper bag is placed inverted over the whole instrument, and, except in the severest gusts, the ball is kept free from hoar frost. A coating of glycerine smeared on the outside of the bag tends to prevent the frost penetrating the paper. Hood and bag are removed before sunrise the following morning.

When frost has to be removed from the ball, it is generally found that as fast as it is thawed by one's hands, it congeals again. To obviate this, a little methylated spirit or petrol or some other quickly drying liquid should be poured on the lens. This greatly assists the melted hoar frost to dry off.

F. J. Parsons.

The Observatory, Ross-on-Wye. January 2nd, 1925.

Notes on the Fog of January 10th-12th, 1925

Apropos of the detailed discussion of the great fog of December 10th-11th, 1924, I should like to record a few observations upon the similar occurrence a month later. I spent many hours on January 11th wandering about the north-western suburbs and also central London, noting the distribution and character of the fog, and verified the following observations repeatedly. In the densely-built streets of central London, *e.g.*, Oxford Street,

* See *Meteorological Magazine*, vol. 59, December, 1924, p. 260.

Regent Street, the Strand and Fleet Street, the fog took the form of a dark, pungent, unsaturated haze, leaving pavements and clothes perfectly dry, and causing little hindrance to traffic, the visibility being at least 50 yards. But in all open places, viz., the parks, squares, and Thames Embankment, there was dense saturated water-fog, taking the form of great rolling blankets, very wetting and impenetrable to vision, and completely paralyzing traffic. The contrast in this respect between Trafalgar Square and the adjacent Strand was remarkable. At Hampstead there was thick water-fog, very wet and also very dirty, with hoar-frost on grass and roads, but comparatively little rime on the trees. I do not think it is sufficiently realized that what paralyzes traffic in London is the white mist or water-fog, just as it does in the country and at sea, and that if it were not for the fact that, as a general rule, the real water-fog in central London is confined to the more open spaces, locomotion would hardly be possible at all in bad fogs. Of course, if the water-fog is darkened by smoke the effect is worse, just as fog by night renders locomotion far more difficult than a fog of the same density by day. My experience on January 11th confirms a long previous experience to the effect that central London's fogs are chiefly pungent, dry, smoke-clouds or hazes, which, though often causing the darkness of night, do not hold up street traffic except at places where condensation is actually going on, *e.g.*, the parks, which are invariably pools of water-fog. The consequence is that, if the smoke problem is once effectively solved, inner London will see far less fog than the suburbs or surrounding country where the conditions are more favourable to nocturnal radiation.

In frosty anticyclonic weather, no doubt the river may breed a certain amount of water-fog by the process of "hot water steaming," and I suspect that the dense wet blanket of vapour in which I became enveloped from time to time along the Victoria Embankment on January 11th had some such origin. The dry fog, or as I should personally prefer to call it, haze, on the other hand, which I experienced in the closely built Strand, near by, did not appear to drift at all like the rolling water fog.

Nocturnal radiation fogs seem often to commence as very thin patchy meadow mists, gradually growing horizontally and vertically as the cooling and mixing of the air proceed. It is instructive in this connection to note that on Saturday morning, January 10th, the fog only affected the lower parts of London, leaving Hampstead in sunshine, whereas on Sunday morning, it had increased in depth so as just to reach the summit of the Heath, whilst on Monday morning the summit was completely enveloped.

L. C. W. BONACINA.

27, Tanza Road, Hampstead. January 30th, 1925.

Mr. Bonacina's observations can be given an interpretation which differs in some respects from that set out in his letter. Where there is a great fog, it reaches to a considerable height, say 500 ft., over London. Over the top of the fog, there is clear sky and the radiation from the droplets in the upper surface cools them and promotes further condensation. The ground at the bottom of the fog may be warmer or colder than the fog. In the case of the December fog, the ground, at any rate at Kew Observatory, was warmer than the fog. So far from the fog being made by contact with the ground, it was actually being warmed and to a certain extent the droplets must have been evaporating. In the case reported by Mr. Bonacina, the ground on Hampstead Heath had been cooled by radiation before the arrival of the fog, and contact with the ground may have caused the deposit of some of the moisture as rime. In both cases, the fog persisted near the ground, though it was not being made there.

In the streets, on the other hand, the foggy air is warmed not only by contact with the outer walls of buildings, but by mixing with the air leaking out from warm rooms and with hot gases from chimneys. The result is that the water drops evaporate, and the air is dry. A circulation is set up between the ground and the top of the fog and the descending currents bring down their quota of smoke to keep the fog black.

As Mr. Bonacina suggests in his concluding remarks, there must be two processes at work in the early stages of fog formation. To begin with, the ground cools by radiation and the air is cooled by contact with the ground. Warmer air, drifting over this cool air and mixing with it, forms wisps of cloud. Directly these wisps are formed, they start cooling by radiation and, if circumstances are favourable, they become the nucleus of a fog.

F. J. W. W.

Eclipse Readings

I SEND the following observations for what they are worth :—

Time.	Dry Bulb.	Wet Bulb.	Grass.
14 h. 46 m.	44·9	42·8	45·1
15 h. 20 m.	43·7	42·0	39·2
15 h. 49 m.	42·3	41·0	33·4
16 h. 32 m.	39·1	38·1	29·3

Sunset by calculation, 16 h. 33 m.

Sky partially clear, but persistent cloud over the sun.

H. NOWELL FFARINGTON.

Worden, Leyland, Preston. January 28th, 1925.

Heavy Rain with High Barometer

On January 26th, with a shallow depression over the western end the English Channel, and an anticyclone covering most of the British Isles, remarkably heavy rain was experienced in the south-west. The Meteorological Office reported 2 in. in 24 hours at Exmouth, and other high totals on coasts of Devon and Cornwall. At this station we had 0·79 in., with an east wind and barometer varying between 30·30 in. and 30·38 in. This is the most remarkable fall in conjunction with a high barometer that I have ever noticed. The maximum temperature on 26th was 38° F., and part of the precipitation fell as snow at 1,000 ft. and all of it in this form at 2,000 ft.

R. P. Dansey.

Kentchurch Rectory, Hereford. January 28th, 1925.

Rainfall Records

I fully agree with the Editor of *British Rainfall* * that there is no advantage in publishing both daily and monthly records where two gauges are used, but I am still of opinion that it is very desirable to keep both. I cannot give a better example than that in the *Meteorological Magazine* for January—the rainfall at Ross (only 12 miles distant) is there given as 4·03 in., while mine was only 2·83 in. Had it not been that my record was verified by my monthly gauge, I might have questioned its accuracy.

Spencer H. Bickham.

Underdown, Ledbury. February 3rd, 1925.

A Strong Leeside Eddy in the Lake District

I was on Red Pike on January 1st, 1925. Red Pike is 2,500 ft. high and is part of the ridge which separates Ennerdale from the Buttermere Valley. The next summit to the south-east is High Style. Between the shoulders of Red Pike and High Style, there is on the Buttermere side of the ridge a coombe containing a tarn, Bleabury Tarn. On this occasion the wind was from the west on the top of Red Pike, but 400 ft. lower in the coombe the wind was from the east, blowing back towards the ridge. On the top of the ridge, the wind was so strong we could hardly stand up against it. To estimate the speed of the wind in the coombe, I timed with the aid of one of my friends, the passage of spindrift along the tarn. It took 8 seconds for 180 yards, so the speed was about 47 miles an hour, even with no allowance for friction.

Richard W. Hall.

5, *Morland Place, Cockermouth. January 9th*, 1925.

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* British Rainfall, 1923, p. x.

Typhoon at Hong Kong

WITH reference to the article in the *Meteorological Magazine* for August, 1924, on the Hong Kong typhoon of August 18th, 1923, I beg to inform you that the Dines Anemograph of this Observatory was calibrated to-day, with the following results :—

First Set.			Second Set.		
Velocity.		Correction to Dines.	Velocity.		Correction to Dines.
By Dines.	True.		By Dines.	True.	
miles.	miles.	miles.	miles.	miles.	miles.
11	8	—3	12	11	—1
26	22	—4	29	25	—4
41	37	—4	49	44	—5
62	57	—5	64	60	—4
77	72	—5	80	73	—7
107	104	—3	103	100	—3
122	118	—4	124	121	—3

J. J. CLAXTON.

Royal Observatory, Hong Kong, September 19th, 1925.

[It will be remembered that the highest gust during the passage of the typhoon in question was recorded as 130 miles an hour. The correction —3 indicated by Mr. Claxton's calibration reduces this to 127 m.p.h. It is still the highest wind speed ever recorded autographically. It may be presumed that the calibration was made according to Mr. Dines's formula * $W = \cdot 00073 V^2$, in which W is the pressure difference measured in inches of water between the inside and outside of the float and V is the wind speed in miles per hour. Ed. *M.M.*]

Line Squall—January 31st, 1925

THE following is an account of the shortest and sharpest line squall I have witnessed here during the last nine years.

Steady wind of force 8, twenty minutes preceding squall, decreased to force 7 on commencement of rain, when pressure rose about 0·6 mb. Strongest gusts about 53 m.p.h., at 16 h. 10 m. when hail commenced ; barometer then rising nearly 2 mb. abruptly. Hail was unusually transparent, more like frozen

* *Observer's Handbook*, 1919, p. 85.

rain. Temperature fell over 11° in rear of squall (48° F. to 37° F.).

The usual long roll of black cloud was in line, SW'W—NE'E. No evidence of precipitation at 15 h. 30 m.: only 40 minutes then elapsing during which the squall appeared and broke overhead.

Precipitation about 4 m.m.

M. W. BINNS.

Market Street, Lutterworth. February 1st, 1925.

NOTES AND QUERIES

Wind and Light Railways

OUR frontispiece illustrates the wreck of a train on the Owencarra viaduct in the north of Ireland, on January 31st, when 4 people lost their lives. The viaduct is on the railway which runs from Letterkenny to Burton Port, on the west coast of Donegal. The Owencarra glen, being nearly straight, and bearing south-west to north-east, the bridge is exposed to the force of gales from the south-west. On this occasion, there were gales all along the north coast of Ireland, but no independent evidence as to the strength of the wind which overturned the train, or, as to whether it was a steady wind or a squall, is available.

It is of interest to remember that there is another light railway in Ireland, in County Clare, where precautions are taken to avoid the risk of an overturned train. At Quilty, on this line, an anemograph is installed with a warning device by which a bell is rung when the wind exceeds 65 miles an hour. When this occurs, so much pig-iron is put into each railway carriage as ballast. When 85 miles per hour is reached, the trains have to stop running. Perhaps similar precautions are desirable on the Burton Port line.

A Plunge through a Line Squall

THE following account of the experiences of Pilot G. P. Olley in a line squall on December 31st, 1924, is published by the courtesy of Imperial Airways, Limited. Pilot Olley was flying a twin engine Handley Page from Paris to London with passengers and freight. He encountered the squall near Marden, a station on the railway from Ashford to Tonbridge, the straight line which is such a conspicuous feature of the map of Kent. We are informed that it is not unusual for pilots to fly through squall clouds, but it is exceptional for them to be carried up so quickly and so far in the rising current.

"On arriving near Marden at about 14h. 50m., I encountered a severe line squall, stretching as far as I could see W to E (or perhaps W by S to E by N), so I decided to go through and

underneath it. On entering the storm at about 400 ft. altitude, I found my machine gradually lifting, and throttled down my engine to obviate this, but without effect.

My machine continued to rise steadily. In the space of about a minute and a half I found myself at an altitude of about 2,800 ft. and came right out on top of the storm where I received a huge downward bump.

I then carried on above the storm which was about five miles in width. When in the storm and cloud, I kept the speed of my machine at a little above ordinary cruising speed. On entering the storm I encountered a heavy deluge of rain and hail, but after rising to about 1,800 feet this ceased. The highest parts of the cloud were at about 4,000 ft.

G. P. Olley, Pilot."

The circumstances of the line-squall were somewhat unusual. Throughout the day, December 31st, there were west winds across England. The conditions were typical of polar air with squally showers of rain, hail, sleet and snow and local thunderstorms. Pronounced line-squall phenomena were limited to a relatively small area. A curious feature was that this particular squall occurred slightly behind the trough of low pressure, the barometer having risen for over an hour previously. The squall did not much exceed 50 miles in length. At South Farnborough, a large mass of false cirrus up to an estimated height of fully 15,000 ft. was visible for over an hour before and after the passage of the squall, and there was a display of mammato-cumulus on the lower rear portion of the " anvil," unusually well developed for the time of year. As the squall crossed London, the bearing of the front was from SW to NE. South Kensington (where the first drop of temperature was 9° F.) was passed at 13h. 36m., Croydon at 13h. 50m. At Shoeburyness at 14h. 40m, an extreme velocity of 73 miles an hour was shown by the anemometer.

It would seem that the cloud front wheeled to the right about this time, as it was almost facing south when Pilot Olley encountered it, at 14h. 50m. This change of direction is consistent with the fact that the squall reached Lympne, 24 miles ESE of Marden, at 14h. 55m. There was no rain at Lympne and the fall of temperature was only 3° F. The report that the top of the cloud was only 4,000 ft. up, suggests that the squall was on a much smaller scale at Marden than it had been at South Farnborough. This makes the strength of the upward current, at least 40 ft. per second, all the more remarkable.

Any additional information, either from autographic records or from weather diaries or the personal recollections of observers, would be valued by the Meteorological Office.

The Gales at the end of 1924

THE recent gales produced abnormally high tides at Calshot (at the mouth of Southampton Water). On November 27th, the meteorological station, 9 ft. above Ordnance datum, was flooded to the depth of a foot, the water being 4 ft. above the normal level for spring tides. The gale and high tide caused considerable damage in the neighbourhood, telephonic communication around Southampton being interrupted and the sea wall destroyed in several places. At 3h. a gust of 68 m.p.h. occurred—the highest since records have been available at Calshot. During the afternoon the wind abated in a very regular manner, becoming practically calm at 18h. A month later (December 27th) a similar gale occurred, but the enclosure escaped being flooded to the same extent. As an indication of the squally weather at the end of 1924 it may be mentioned that from January 1st, 1921, to November 26th, 1924, the total number of gusts recorded which exceeded 54 m.p.h. was 200, whilst from November 27th, 1924, to January 4th, 1925, there were approximately 400.

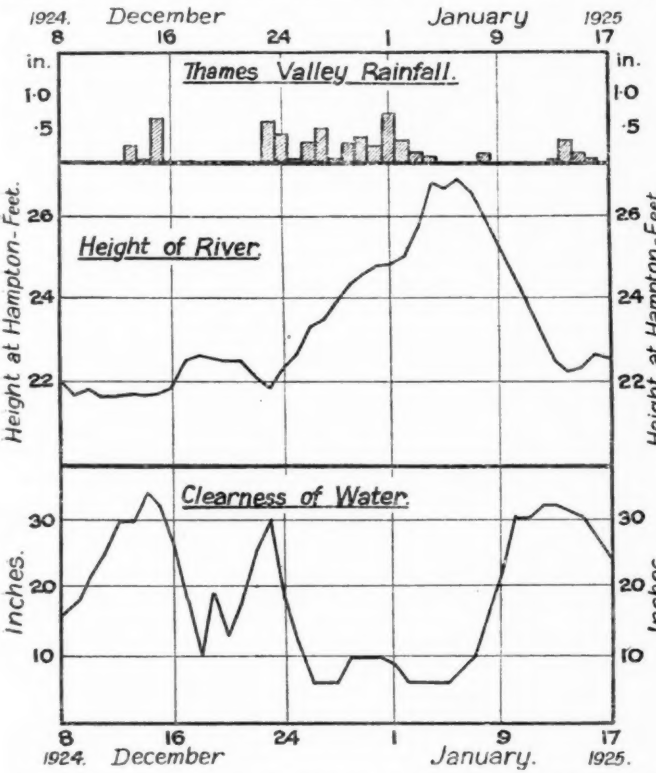
The Floods in the Thames Valley

THE persistent rain at the end of December, 1924, and in January, 1925, led to serious floods in many parts of England; notably in the Thames Valley. By the courtesy of Dr. Houston, of the Metropolitan Water Board, we are able to show in the accompanying diagram the fluctuations in the height of the river during the period from December 8th to January 17th. For comparison, the rainfall for each day averaged over the whole of the Thames Valley is also shown. It will be seen that after heavy rain on December 15th the river rose about 18 in., but it was at the normal winter level when the wet spell began on December 23rd. From that day to January 6th there was a steady rise. It will be seen that the floods were due to the recurrence of rain before the run-off from the land to the river had time to get away to the sea. The fact that the rain came at the end of a wet year had not much to do with the matter. The only preliminary condition is that the ground is sufficiently wet for the rain which falls on the country-side to run off, instead of being absorbed.

According to Lord Desborough's report to the Thames Conservancy Board, the maximum flow of the Thames at Teddington Lock was $9{\cdot}4 \times 10^9$ gallons per day on January 4th. Since the basin above Teddington has an area of 3,800 square miles, 1 in. of rain produces 56×10^9 gallons, and it follows that the Thames in flood can dispose of ·17 in. in a day. At the normal level the flow is $4{\cdot}5 \times 10^9$ gallons, equivalent to ·08 in. a day. The rainfall of the period, December 23rd to January 13th, when the river

was rising and falling again, was equivalent to an average ·19 in. a day. It is clear that most of the rain was accounted for by the flow at Teddington.

The rate at which the river fell at Hampton serves as a rough index of the extent of the floods. The fall was about 8 in. a day,



and, in the absence of information, it is reasonable to assume that this was the rate up and down the river. The flow of $9{\cdot}4 \times 10^9$ gallons would dispose of 8 in. of water from an area 200 miles long and 2,000 ft. wide. Suppose that half the water coming down was fresh drainage from the land, and half from the floods, then the flooded area would have been 200 miles long and 1,000 ft. wide. This estimate is fairly consistent with the descriptions in the newspapers.

The Clearness of Thames Water after Floods

In the diagram on *p.* 15, the variations in the clearness of the Thames Water are shown. The observations utilised are made at Staines. The measurement recorded is the depth at which a white circular disc about 6 in. in diameter disappears when lowered into the water. It will be seen that the water became more turbid whilst the floods were rising, but that a high standard of clearness was reached before they had subsided. The unusual clearness was conspicuous enough to attract attention as far down the river as Richmond. No doubt the water is cleared by the deposit of silt on the riverside meadows.

The Control of Fire-Damp by Atmospheric Pressure

In a letter from Dr. J. R. Sutton, published in the *Meteorological Magazine* for October, 1924, it is stated that " the fact that fire damp in mines may be most dangerous when the barometer is low or rather falling, is of course well-known." Mr. H. Harries who has given much attention to such questions writes to point out that, according to Dr. Sutton's diagram, the maximum production of firedamp at Kimberley did not occur when the barometer was falling. The high correlation is as Dr. Sutton mentions earlier in his letter between the rate of issue of the gas and the pressure itself, it is not between the rate of issue and the rate of change of pressure. Dr. Sutton's remark would be justified, however, if accidents occur when the amount of firedamp is increasing, and are rare when it is decreasing. The human element in such questions should not be ignored. It must be added that Mr. Harries believes that the statistical evidence is against the hypothesis that accidents due to firedamp are more common in British coal mines when barometric pressure is low. He claims to have found the opposite principle the basis of successful forecasts of dangerous conditions.

The Sound of the Explosions at La Courtine

A preliminary report on the observations made on May 15th and May 23rd, when explosions were made at La Courtine in central France, has been published by M. Charles Maurain. On each of these occasions there was a zone of normal audibility, mostly to the north of La Courtine. Outside a wide zone of silence there were areas of abnormal audibility. On May 15th there were two such areas to the east and to the west. On May 23rd there seems to have been a continuous area to the east and south. The inner boundary of these areas of abnormal reception was about 180 kilometres from the source of sound. The apparent speed of the sound averaged about 290 metres per

second. This speed is in accordance with the hypothesis discussed in the *Meteorological Magazine* last April, according to which the sound waves return to earth after reaching the "empyrean," the warm region, which, according to Lindemann and Dobson, exists at 50 kilometres or more above the ground. The radius of the zone of abnormal audibility is smaller than that given by the hypothetical distribution of temperature, 322 kilometres. It may be that the transition to the empyrean is well below 50 kilometres, say, at 30 kilometres. M. Maurain says nothing of the empyrean in his note; he merely remarks that the relation of sound waves to the ground appears to depend on the distribution of wind and temperature.

F.J.W.W.

Radiation from the Sky

RADIATION MEASURED AT BENSON, OXON, 1924.

Unit: one gramme calorie per square centimetre per day.

ATMOSPHERIC RADIATION only (dark heat rays).

Averages for Readings about time of Sunset.

		Oct.	Nov.	Dec.
Cloudless days:—				
Number of readings	n	7	4	9
Radiation from sky in zenith ...	πI	528	463	463
Total radiation from sky ...	J	565	495	499
Total radiation from horizontal black surface on earth ...	X	741	656	665
Net radiation from earth ...	$X—J$	176	161	166

DIFFUSE SOLAR RADIATION (luminous rays).

Averages for Readings between 9 h. and 15 h. G.M.T.

		Oct.	Nov.	Dec.
Cloudless days:—				
Number of readings	n_0	6	2	5
Radiation from sky in zenith ...	πI_0	27	15	16
Total radiation from sky ...	J_0	33	17	23
Cloudy days:—				
Number of readings	n_1	6	5	2
Radiation from sky in zenith ...	πI_1	102	34	21
Total radiation from sky ...	J_1	81	27	17

Unit for I = gramme calorie per day per steradian per square centimetre.

Unit for J and X = gramme calorie per day per square centimetre.

For description of instrument and methods of observation, see *The Meteorological Magazine*, October, 1920, and May, 1921.

Acoustic Clouds

In an article in *Nature*,* discussing the growing demand for the solution of acoustical problems which are beginning to affect our everyday life, and the lack of research work done in this subject since the war, Major Tucker says: "The ease with which these instruments (the Service sound locators for the detection and location of aeroplanes) can be used depends on the structure of the atmosphere in which, apart from the refraction due to the above causes, there are irregularities due to local temperature and humidity variations, and local whirls and eddies. These variations in the medium have all been grouped under the heading of 'acoustic clouds.'† Contrary to what might be expected, these acoustic clouds are most in evidence on a warm sunny day of good visibility, and are undoubtedly due to unequal heating from the sun's radiation. After sunset these clouds dissipate, and we get, not only good listening as regards range, but also greatly improved powers of finding direction. The blurred acoustical image becomes well defined. On the other hand, a uniform fog is acoustically clear and it is only on the fringes of the fog that sound absorption takes place. Experiments have recently been performed with aeroplanes in which some idea of the dimensions of the acoustic clouds has been deduced. These have been obtained by taking a photographic record of the sound obtained from an aeroplane in flight, and observing the periodicity of the sound fluctuations.

"One of the outcomes of the study of meteorological conditions has been the fixing of an 'acoustic sky-line' which, under adverse wind conditions, always lies above the visual skyline. A source of sound moving through the air may be observed to rise or set over the skyline, with a definiteness almost as complete as the rising and setting of the sun, and when the sound is below the skyline a kind of acoustic twilight is produced. At this stage sense of direction is lost, the sound is diffused, and only arrives at the observer or microphone by scattering."

Terrestrial Magnetism and Seismology at the Meteorological Office Observatories

With regard to a recently published article on terrestrial magnetism and seismology‡ Dr. Chree writes, that, in his opinion, the statement that the magnetic records for Kew Observatory "have been thoroughly discussed" requires some qualification. Two investigations making use of the magnetograms of past years

* Vol. 114, 1924, p. 689.

† See J. Tyndall, "On the Atmosphere as a Vehicle of Sound," *London Phil. Trans. R. Soc.*, 1874, *p.* 183; and J. Tyndall. *Sound*, 3rd Edition, ch. vii.

‡ *Meteorological Magazine*, Vol. 59, November, 1924, p. 242.

are in progress, and much useful work could still be done on the magnetograms of years prior to the electrification of trams and railways. Also, while considering the Lerwick Observatory a most valuable addition to existing sources of knowledge, Dr. Chree thinks that additional observatories in the Hebrides (or north-west Scotland) and in western Ireland would probably be of great value for the elucidation of the phenomena of magnetic storms.

Advantage may be taken of this opportunity to correct a mis-statement as to the position of Eskdalemuir Observatory. The observatory is not 17 miles from the nearest railway line. It is 17 miles by road from the most accessible main line station, Lockerbie. The distance by road from the post town, Langholm, is 16 miles. The nearest railway station is actually Moffat, just over 9 miles across the moors. The railway between Beattock and Wamphray stations comes within 8½ miles.

Local Rainfall Associations

THE collection and publication of rainfall records by various local associations throughout the country does much to stimulate and maintain interest in the subject, and official meteorology is indebted to those enthusiasts who for many years have voluntarily co-operated in such work and placed the results of their labours at the disposal of the Meteorological Office. In the majority of such associations the bulk of the work falls upon the collector, whose enthusiasm ensures continuity so long as he is able to deal with the clerical and arithmetical work involved. Changes are about to take place in three such associations, each with a long history, but it is cause for satisfaction that in two cases the work will be carried on without a break.

The Croydon Natural History and Scientific Society has published each month rainfall and other meteorological records from upwards of 100 stations in Surrey and adjoining counties. These records have been carefully complied by Mr. F. Campbell-Bayard for 37 years. The publication involved a heavy financial burden on the Society, and, as Mr. Campbell-Bayard was beginning to feel the strain of his onerous task, it has been reluctantly decided that publication must cease. In order that no records may be lost, all the contributing observers have been asked to forward their results direct to the Meteorological Office in future.

The Mid-Wessex Rainfall Association loses an earnest and inspiring worker in the Rev. H. A. Boys. Mr. Boys's interest in local meteorology dates back for 60 years. His interest in the rainfall of Wessex was such that, on his removal from North Cadbury Rectory (Somerset) to St. Marybourne (Hampshire) some years ago, he voluntarily continued the collection of the records from a distance rather than allow the work to lapse.

He is compelled to relinquish it on account of his advanced age and failing sight, but is making arrangements for the work to be carried on.

The work of compiling the meteorological reports and tables for the Northamptonshire Natural History Society, has been carried out with conspicuous success since January, 1889, by Major C. A. Markham. He is succeeded by Mr. R. H. Primavesi, who undertook the duties during the Great War.

Keswick Diary of the Eighteenth Century

PRIOR to the introduction of organised schemes in the second half of the nineteenth century, the recording of the weather was dependent on the enthusiasm and industry of a few observers who at different periods and for varying lengths of time maintained continuous records of weather changes in their own districts. Some of these weather diaries have been preserved, the earliest known diary being one which was kept at Oxford by William Merle, Fellow of Merton College, from January 1337, to January 1344, now in the Bodleian Library.

The diary which is the subject of this note and for the loan of which we are indebted to Miss Marshall, was kept at Keswick, by Peter Crosthwaite during the period August 1787, to December 1795. There are nine manuscript volumes of foolscap size in excellent condition. The diary comprises observations of pressure, temperature, rainfall, humidity, wind direction and force, amount of sky covered with cloud, cloud height in yards together with notes of remarkable occurrences. The last volume contains a few remarks on the weather during each of the years 1796 to 1803. An interesting account of the diarist by his grandson, John Fisher Crosthwaite, is given in the Transactions of the Cumberland Association for the Advancement of Literature and Science, Part III.

Observations were taken three times a day, at the hours which we should now call, 7h., 12h., and 18h. in summer, and at 8h., 12h., and 16h. in winter. At the beginning of the diary, barometer readings are given in degrees and tenths which suggests that the instrument then in use may have had a lever which moved over a graduated dial. On April 1st, 1788, a new inch barometer was obtained, and at the same time a new Fahrenheit thermometer. About twelve days after this, the latter instrument was moved from its position indoors where it had hung at a distance of 15 feet from a fire, and mounted outside in the shade on the north side of the house. By a comparison with a new Hollin thermometer about five years later this instrument was found to read 3° F. too low, but the diarist continued to use it, and there is no evidence as to whether any correction was applied.

Wind direction is given to 32 points of the compass and force

is expressed on the scale 0-12, 0 indicating a calm, and 12 a hurricane. The number of hurricanes recorded seems rather excessive for a place like Keswick. A comparison of the number of days of gales during the 5 years, 1919-1923, with the number of days of hurricanes during the 5 years, 1791-1795, yielded the following results :—

	1791	1792	1793	1794	1795
No. of days of hurricanes ..	39	13	9	13	5
	1919	1920	1921	1922	1923
No. of days of gales ..	2	4	3	3	2*

The term "hurricane," has no doubt been used more in the sense of "gale," than in its modern sense. There is evidently no correspondence between the scale employed by Peter Crosthwaite and that adopted by Admiral Beaufort in 1805 for use at sea and now used at land stations such as Keswick.

Rainfall observations commenced on April 1st, 1788. The rain was collected at the time of the evening observation, weighed, and the weight converted into depth in inches, results being given to four places of decimals. The results for the period 1788-1792, were discussed by John Fisher Crosthwaite, grandson of the diarist, in an article in the Transactions of the Cumberland Association for the Advancement of Literature and Science, Part II,, entitled "The Rainfall of Keswick." Observations of cloud amount extend from January 20th, 1788, to the end of 1791, and the precision with which the results are stated is sometimes startling. Thus, on February 1st and 10th, the proportion of sky covered by cloud at 7 a.m., was estimated to have been $\frac{1}{1500}$ and $\frac{1998}{2000}$ respectively! The height of the clouds above Derwent is given in yards and was probably estimated by reference to mountains, the heights of which were known. Observations of the humidity of the air which commenced on April 10th, 1788, ceased at the end of 1791.

Aurora was observed on 57 occasions, between August, 1787, and December, 1795. An interesting item is the note of April 21st, 1789, referring to an observation of Uranus discovered by (Sir) William Herschel on March 13th, 1781. The note runs as follows :—"At 10 last night saw for the first time with Dollands Glas the Georgium Sidus about ½ a degree W. of Mars."

The diary includes phenological observations and intimate notes about affairs in the district. The following extract is of historical interest :—

> April 2nd, 1789. The greatest rejoicings that ever was known in Britain on account of the recovery of our very good King and the most sincere addresses to Him and our virtuous Queen on the same account.

P.I.M.

* October missing

Review

Climatic Laws—A Summary of Climate. By S. S. Visher, Ph.D. (Chicago). Size $9\frac{1}{4} \times 6$, pp. 96. *Illus.* New York: John Wiley & Sons, Inc., & London: Chapman & Hall Ltd., 1924. 7s. 6d. net.

The variations of climate over the globe are so intricate that he who sets out to make serviceable and easily remembered generalizations deserves our gratitude. Dr. Visher has read widely, and has collected no less than ninety generalizations. He has, however, handicapped himself unduly, for he eschews all mathematical symbols. Moreover, there is only one little table in his book, the only maps are charts covering the whole world, and graphs occur only in a pair of diagrams to which there is no reference in the text.

As a sample of the quality of the work, we quote at random one of the shorter paragraphs.

" 59. *Atmospheric humidity, both absolute and relative, averages less at the earth's surface in windy areas than in calm areas, otherwise similar,* because in windy areas, the moistened lower layers of air are soon mixed with or replaced by drier air from above. Upward convection is the agent which does most to prevent the surface air from being excessively humid. As water vapour is lighter than the other constituents of the surface air, moist air is forced to rise and is replaced by heavier and drier air. The height to which it can ascend is limited by condensation and by gravity. An exception to this rule of decreased humidity with increased windiness often occurs in the centres of Highs, where, in spite of slight windiness, humidity is often relatively low because of descending air."

This paragraph is open to several criticisms. In the first place the " generalization " printed in italics is of little value without some guide to tell us how " otherwise similar " areas are to be identified. Within the confines of the British Isles the rule is for the windy areas to be the damp ones: no doubt that is because these areas are not " otherwise similar." Merely as a theoretical statement the generalization is open to the criticism that the greater efficiency of moving air in promoting evaporation is ignored. The next two sentences seem to imply that convection is due in the main to the fact that damp air is lighter than dry air at the same temperature. Is there any evidence that this slight difference is an effective cause of air movement at all? We know of none. The significance of the reference to gravity in the penultimate sentence of the quotation eludes us.

This may not be quite a fair average sample of the work, but when the reader has noted a few cases of loose writing he becomes sceptical about every statement. What is to be made of the

following generalization ? (p. 71) : " *Local contrasts in the amount of rainfall are greater in tropical than in higher latitudes among topographically similar places, with the exception of the doldrums.*" The only evidence quoted in support of the generalization refers to the Hawaiian islands. In what way conditions are exceptional in the doldrums is not stated or even hinted. Perhaps the most elusive remark of all is with regard to air pressure (p. 85) : " At 5,000 feet there are appreciable effects on some climatic elements, especially upon the rate of cooling in the shade, and some people are made nervous." Are these good people nervous because they cool too quickly or for some more occult reason ?

The great merit of a book like this is that it encourages the spirit of enquiry : any of the generalizations might be chosen as the subject for a thesis and the search for the statistical and physical justification would in every case be a valuable exercise for the student of climatol gy. We hope that Dr. Visher will receive many such theses, and use them in the preparation of a second edition of his book.

News in Brief

THE Fourth Annual Dinner of the Meteorological Office Staff at Shoeburyness, was held at the Queen's Hotel, Westcliff, on Saturday, January 17th, 1925. The guest of the evening was Capt. D. Brunt, Superintendent of Army Services. An excellent entertainment by members of the staff followed the dinner.

The Weather of January, 1925

SOUTH to south-westerly winds and a temperature well above the average were the main characteristics of the weather of January. During the first few days there was a continuance of the rough weather which prevailed towards the end of December, and gales were experienced in many parts of the country. In some districts the average wind velocity reached about 60 m.p.h. (Beaufort force 10), while 80 m.p.h. was attained in gusts at Weaver Point on the 1st, and Southport on the 2nd. Heavy rain occurred locally during these first two days, the heaviest falls being in Wales and Westmoreland, where 99 mm. (3·90 in.) occurred at Blænau Brecon on the 2nd, and 51 mm. (2·00 in.) at Orton (Westmoreland) on the 1st. " Snow lying " was recorded in Scotland and northern England during the first week, a depth of 5½ in. being registered at Balmoral on the 3rd. In the rear of a secondary depression which crossed the British Isles on the 3rd and 4th, a ridge of high pressure spread northwards to Iceland from the Azores anticyclone, and a period of fairer, colder weather set in which, except for the passage of a

V-shaped depression causing rain generally, lasted nearly a week. Six or seven hours of bright sunshine were experienced on several occasions and some low minimum temperatures were recorded. By the 10th, the western districts of Ireland and Scotland came under the influence of depressions passing north-eastwards across the Atlantic. Anticyclonic conditions, however, still persisted in the south-east, and dense fog prevailed over a wide area in and around London from the 10th to 12th. On the 11th, temperature did not rise above 32° F. at several stations. By the 13th, mild conditions with strong south-westerly and local rain had spread over the whole country. Gusts of more than 70 m.p.h. were recorded in some parts, the highest one (95 m.p.h.) occurring at Lerwick on the 14th. Rainfall amounted to nearly 50 mm. (2 in.) at many places in Ireland. Between the 15th and 22nd there was a change to sunny, drier conditions, with local mist and fog, but after the 22nd the weather again became unsettled and there was much rain, especially in south-west England, on the 25th and 26th *e.g.*, 48 mm. (1·88 in.) fell at Ippleden, Devon, on the 25th), and in the north of England on the 29th and 30th. Snow occurred in parts of Scotland, and also in Ireland and north England on the 31st. On the 29th to 31st gales were experienced at several places. The rainfall for the month varied generally from about 75 per cent. of the normal to 150 per cent., but at Ashburton (Devon) and at Brighton there was more than twice the normal, while at Beccles there was only half the normal.

ON the average, pressure was much above normal over central and southern Europe and the Mediterranean, the excess being 14 mb. at Nice, 10 mb. in Switzerland, and 5 mb. in the south of Sweden. In the north, pressure was below normal, the deficit being 7 mb. over Iceland, 8 mb. in the north of Sweden, and 13 mb. at Spitzbergen. The pressure distribution favoured warm south-westerly winds, and the temperature was abnormally high ; at Haparanda, on the Gulf of Bothnia, the mean temperature at 7h. (G.M.T.) was 28° F., as compared with the normal for January of 11° F. Rainfall was about normal in most parts of Europe. Generally unsettled weather prevailed during the first few days of the month, heavy rain fell in the Rhine Basin and floods were widespread there, but an anticyclone spread from the Atlantic on the 6th, and gradually extended over all central Europe, where it persisted until nearly the end of the month. During this period, fogs were reported from most districts : especially in France. The Mediterranean region enjoyed mainly fair weather until the last few days of the month. Some rather low temperatures were recorded, 21° F. at Milan on the 10th and 14th, and 25° F. as far south as Colomb-Béchar in the Sahara on

the 14th. A report from Italy concerning the first ten days of January showed that the weather had been fairly favourable for the crops in all districts. On the other hand, there was a great shortage of water in Switzerland and Austria. Northern Europe was unaffected by the anticyclone and experienced some very stormy weather. Rainfall in southern Sweden was about 40 per cent. above normal, the weather being generally favourable for agriculture.

Reports from Persia show that there has been heavy rain in Kain and Seistan, and an expedition from Guinea (West Africa) to Lake Chad was also greatly hampered by floods.

Canada and the United States still suffered from intense cold and widespread snowstorms. At White River (Ontario), air temperature went down to —48° F. on the 14th, at Doucet (Quebec), it was —52° F. on the 19th and —54° F. on the 27th, and at Canton —42° F. on the 28th. Newfoundland had exceptionally stormy weather. The St. Lawrence River froze for a stretch of 100 miles from Lake Ontario. A severe snowstorm swept across the N.E. United States on the 30th.

A tropical cyclone passed over the northern part of western Australia on the 25th, doing much damage, especially to the town of Melbourne. The rainfall was slightly above normal for the month in Western Australia, Victoria, and New South Wales, but elsewhere it was above normal.

Mr. Mossman writes me that in Buenos Aires, the most severe drought on record was brought to an end by a violent thunderstorm on the 12th, during which 121 mm. of rain fell in seven hours, the streets were flooded, and much damage done. From September 15th, 1924, to January 11th, 1925, only the total fall was 84 mm., December was remarkably warm, and in the first eleven days of January, the mean daily maximum was 92·8° F. (8·1° F. above normal) and the maximum exceeded 103° on the 6th.

The special message from Brazil states that the rainfall was scanty in the central regions, being 95 mm. below the normal for January, and irregular though mostly below the normal in the southern regions. Depressions passed across the country more frequently than in the preceding months, and the areas of high pressure were unusually far to the south. Crops are generally in good condition. At Rio de Janeiro, pressure was 1·5 mb. above the normal, and temperature 0·5° F. below normal.

Rainfall January, 1925—General Distribution

England and Wales ..	107	per cent. of the average 1881-1915.
Scotland	106	
Ireland	114	
British Isles	108	

Rainfall: January, 1925: England and Wales

CO.	STATION.	In.	mm.	Per-cent. of Av.
Lond.	Camden Square	2·01	51	108
Sur .	Reigate, Hartswood	3·13	79	139
Kent.	Tenterden, View Tower	2·98	76	139
,, .	Folkestone, Boro. San.	2·24	57	...
,, .	Broadstairs, St Peter's	1·08	27	62
,, .	Sevenoaks, Speldhurst.	2·86	73	...
Sus .	Patching Farm	4·93	125	190
,, .	Brighton, Old Steyne	5·39	137	229
,, .	Tottingworth Park	4·49	114	166
Hants	Ventnor, Roy.Nat.Hos.	6·40	163	249
,, .	Fordingbridge, Oaklnds	4·59	117	166
,, .	Ovington Rectory	4·18	106	155
,, .	Sherborne, St.John Rec.	3·03	77	130
Berks	Wellington College	2·30	58	116
,, .	Newbury, Greenham	2·64	67	114
Herts.	Bennington House	1·57	40	86
Bucks	High Wycombe	2·36	60	113
Oxf. .	Oxford, Mag. College	1·52	39	88
Nor .	Pitsford, Sedgebrook	1·39	35	75
,, .	Eye, Northolm	0·86	22	...
Beds.	Woburn, Crawley Mill.	1·41	36	82
Cam.	Cambridge, Bot. Gdns.	1·29	33	86
Essex	Chelmsford, County Lab	1·45	37	95
,, .	Lexden, Hill House	1·14	29	...
Suff .	Hawkedon Rectory	1·00	25	57
,, .	Haughley House	0·85	22	...
Norf.	Beccles, Geldeston	0·85	22	51
,, .	Norwich, Eaton	1·07	27	55
,, .	Blakeney	1·35	34	78
,, .	Swaffham	0·87	22	47
Wilts.	Devizes, Highclere	2·68	68	123
,, .	Bishops Cannings	2·87	73	124
Dor .	Evershot, Melbury Ho.	4·78	121	138
,, .	Weymouth, Westham	4·42	112	182
,, .	Shaftesbury, Abbey Ho.	3·24	82	125
Devon	Plymouth, The Hoe	4·31	109	130
,, .	Polapit Tamar	4·30	109	116
,, .	Ashburton, Druid Ho.	10·60	269	208
,, .	Cullompton	3·48	89	107
,, .	Sidmouth, Sidmount	4·71	120	165
,, .	Filleigh, Castle Hill	4·74	120	...
,, .	Barnstaple, N.Dev.Ath.	3·17	81	97
Corn.	Redruth, Trewirgie	4·29	109	102
,, .	Penzance, Morrab Gdn.	3·28	83	87
,, .	St. Austell, Trevarna	5·03	128	118
Soms	Chewton Mendip	4·81	122	125
,, .	Street, Hind Hayes	2·24	57	...
Glos. .	Clifton College	3·23	82	114
,, .	Cirencester	2·49	63	97
Here.	Ross, Birchlea	2·40	61	99
,, .	Ledbury, Underdown.	1·99	51	90
Salop	Church Stretton	3·02	77	119
,, .	Shifnal, Hatton Grange	1·79	45	92
Staff.	Tean, The Heath Ho.	2·19	56	85
Worc.	Ombersley, Holt Lock.	1·78	45	93
,, .	Blockley, Upton Wold.	1·56	40	66
War.	Farnborough	1·59	40	74
War.	Birminghm, Edgbaston	2·12	54	105
Leics	Thornton Reservoir	1·98	50	100
,, .	Belvoir Castle	2·05	52	116
Rut .	Ridlington	1·54	39	...
Linc.	Boston, Skirbeck	1·19	30	73
,, .	Lincoln, Sessions House	1·36	35	81
,, .	Skegness, Estate Office.	1·50	38	87
,, .	Louth, Westgate	1·80	46	83
,, .	Brigg	1·60	41	89
Notts.	Worksop, Hodsock	1·74	44	98
Derby	Mickleover, Clyde Ho.	2·27	58	112
,, .	Buxton, Devon. Hos.	4·79	122	107
Ches.	Runcorn, Weston Pt.	1·93	49	81
,, . .	Nantwich, Dorfold Hall	2·29	58	...
Lancs	Manchester, Whit. Pk.	2·05	52	82
,, . .	Stonyhurst College	3·86	98	90
,, . .	Southport, Hesketh	2·15	55	85
,, . .	Lancaster, Strathspey.	3·05	77	...
Yorks	Sedbergh, Akay	5·52	140	101
,, .	Wath-upon-Dearne	1·76	45	92
,, .	Bradford, Lister Pk.	4·27	108	148
,, .	Wetherby, Ribston H.	1·97	50	96
,, .	Hull, Pearson Park	1·48	38	82
,, .	Holme-on-Spalding	1·42	36	...
,, .	West Witton, Ivy Ho.	4·15	105	...
,, .	Felixkirk, Mt. St. John	1·61	41	81
,, .	Pickering, Hungate	1·14	29	...
,, .	Scarborough	·		
,, .	Middlesbrough	1·08	27	67
,, .	Baldersdale, Hury Res.	4·37	111	123
Durh.	Ushaw College	1·68	43	82
Nor .	Newcastle, Town Moor.	1·83	47	90
,, .	Bellingham Manor	2·86	73	...
,, .	Lilburn Tower Gdns.	2·11	54	...
Cumb	Geltsdale	3·11	79	...
,, .	Carlisle, Scaleby Hall	2·27	58	92
,, .	Seathwaite	11·10	282	84
Glam.	Cardiff, Ely P. Stn.	4·38	111	116
,, .	Treherbert, Tynywaun	10·70	272	...
Carm	Carmarthen Friary	3·68	93	84
,, .	Llanwrda, Dolaucothy.	6·31	160	119
Pemb	Haverfordwest, School	3·56	90	77
Card.	Gogerddan	4·08	104	100
,, .	Cardigan, County Sch.	3·59	91	...
Brec.	Crickhowell, Talymaes	4·75	121	...
Rad .	Birm.W.W.Tyrmynydd	7·03	179	112
Mont.	Lake Vyrnwy	·		
Denb.	Llangynhafal	2·67	68	...
Mer .	Dolgelly, Bryntirion	4·64	118	82
Carn.	Llandudno	2·04	52	79
,, .	Snowdon, L. Llydaw 9	12·05	306	...
Ang .	Holyhead, Salt Island.	1·98	50	68
,, .	Lligwy	2·03	52	...
Isle of Man				
	Douglas, Boro' Cem.	2·99	76	88
Guernsey				
	St. Peter, Port Grange.	6·25	159	213

Rainfall: January, 1925: Scotland and Ireland

CO.	STATION	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent. of Av.
Wigt.	Stoneykirk, Ardwell Ho	3·08	78	104	*Suth.*	Loch More, Achtary	9·01	229	124
,,	Pt. William, Monreith	3·20	81	...	*Caith*	Wick	1·54	39	63
Kirk.	Carsphairn, Shiel.	9·90	251	...	*Ork.*	Pomona, Deerness	2·96	75	86
,,	Dumfries, Cargen	4·44	113	111	*Shet.*	Lerwick	5·34	136	125
Dum	Drumlanrig	5·06	129	122	*Cork.*	Caheragh Rectory	6·44	164	...
Roxb	Branxholme	3·70	94	135	,,	Dunmanway Rectory	7·49	190	120
Selk.	Ettrick Manse	8·24	209	...	,,	Ballinacurra	4·51	115	113
Berk.	Marchmont House	1·88	48	84	,,	Glanmire, Lota Lo.	5·79	147	135
Hadd	North Berwick Res.	1·37	35	80	*Kerry*	Valencia Obsy.	8·18	208	149
Midl	Edinburgh, Roy. Obs.	2·65	67	151	,,	Gearahameen	14·80	376	...
Lan.	Biggar	4·76	121	179	,,	Killarney Asylum	9·49	241	160
Ayr	Kilmarnock, Agric. C.	3·73	95	109	,,	Darrynane Abbey	5·82	148	116
,,	Girvan, Pinmore	4·30	109	91	*Wat.*	Waterford, Brook Lo.	5·46	139	148
Renf.	Glasgow, Queen's Pk.	4·49	114	134	*Tip.*	Nenagh, Cas. Lough	·		
,,	Greenock, Prospect H.	6·68	170	98	,,	Tipperary	6·90	175	...
Bute.	Rothesay, Ardencraig	4·86	124	108	,,	Cashel, Ballinamona	4·90	125	129
,,	Dougarie Lodge	4·67	119	...	*Lim.*	Foynes, Coolnanes	6·04	153	160
Arg.	Ardgour House	10·48	266	...	,,	Castleconnell Rec.	4·32	110	...
,,	Manse of Glenorchy	7·60	193	...	*Clare*	Inagh, Mount Callan	6·58	167	...
,,	Oban	5·40	137	...	,,	Broadford, Hurdlest'n.	5·16	131	...
,,	Poltalloch	5·02	127	100	*Wexf*	Newtownbarry	·		
,,	Inveraray Castle	7·74	197	94	,,	Gorey, Courtown Ho.	4·24	108	136
,,	Islay, Eallabus	4·37	111	93	*Kilk.*	Kilkenny Castle	4·59	117	143
,,	Mull, Benmore	11·70	297	...	*Wic.*	Rathnew, Clonmannon	3·73	95	...
Kinr.	Loch Leven Sluice	3·79	96	120	*Carl.*	Hacketstown Rectory	4·33	110	122
Perth	Loch Dhu	8·90	226	98	*QCo.*	Blandsfort House	4·00	102	122
,,	Balquhidder, Stronvar	8·28	210	98	,,	Mountmellick	5·14	131	...
,,	Crieff, Strathearn Hyd.	4·21	107	104	*KCo.*	Birr Castle	3·30	84	117
,,	Blair Castle Gardens	3·60	91	108	*Dubl.*	Dublin, FitzWm. Sq.	2·39	61	104
,,	Coupar Angus School	2·66	68	112	,,	Balbriggan, Ardgillan	2·19	56	96
Forf.	Dundee, E. Necropolis	2·01	51	103	*Me'th*	Drogheda, Mornington	2·23	57	...
,,	Pearsie House	2·51	64	...	,,	Kells, Headfort	3·65	93	116
,,	Montrose, Sunnyside	1·45	37	73	*W.M*	Mullingar, Belvedere	3·30	84	103
Aber.	Braemar Bank	4·54	115	147	*Long*	Castle Forbes Gdns.	2·71	69	81
,,	Logie Coldstone Sch.	2·50	63	113	*Gal.*	Tuam, Gardenfield	·		
,,	Aberdeen, Cranford Ho	1·65	42	69	,,	Ballynahinch Castle	5·66	144	...
,,	Fyvie Castle	1·08	27	...	*Mayo*	Mallaranny	6·34	161	...
Mor.	Gordon Castle	1·32	33	65	,,	Westport House	5·07	129	109
,,	Grantown-on-Spey	2·85	72	118	,,	Delphi Lodge	8·02	204	...
Na.	Nairn, Delnies	1·72	44	86	*Sligo*	Markree Obsy.	4·10	104	105
Inv.	Ben Alder Lodge	10·35	263	...	*Cav'n*	Belturbet, Cloverhill	2·96	75	99
,,	Kingussie, The Birches	4·15	105	...	*Ferm*	Enniskillen, Portora	4·02	102	...
,,	Loch Quoich, Loan	17·10	434	...	*Arm.*	Armagh Obsy.	2·21	56	88
,,	Glenquoich	16·26	413	118	*Down*	Warrenpoint	2·59	66	...
,,	Inverness, Culduthel R.	3·16	80	...	,,	Seaforde	4·19	106	133
,,	Arisaig, Faire-na-Squir	6·74	171	...	,,	Donaghadee	2·40	61	95
,,	Fort William	10·38	264	108	,,	Banbridge, Milltown	2·10	53	94
,,	Skye, Dunvegan	5·48	139	...	*Antr.*	Belfast, Cavehill Rd.	3·25	83	...
,,	Barra, Castlebay	2·76	70	...	,,	Glenarm Castle	3·63	92	...
R&C	Alness, Ardross Cas.	4·65	118	122	,,	Ballymena, Harryville	3·17	81	85
,,	Ullapool	6·00	152	...	*Lon.*	Londonderry, Creggan	4·04	103	112
,,	Torridon, Bendamph	10·17	258	108	*Tyr.*	Donaghmore	3·68	93	...
,,	Achnashellach	8·37	213	...	,,	Omagh, Edenfel	4·03	102	114
,,	Stornoway	5·82	148	113	*Don.*	Malin Head	3·11	79	119
Suth.	Lairg	2·81	71	...	,,	Rathmullen	3·61	92	...
,,	Tongue Manse	4 35	111	110	,,	Dunfanaghy	3·66	93	90
,,	Melvich School	3·27	83	99	,,	Killybegs, Rockmount	4·48	114	80

Climatological Table for the British Empire, August, 1924

STATIONS	PRESSURE: Mean of Day M.S.L.	PRESSURE: Diff. from Normal	TEMPERATURE: Absolute Max.	TEMPERATURE: Absolute Min.	TEMPERATURE: Mean Values Max.	TEMPERATURE: Mean Values Min.	TEMPERATURE: Mean Values ½ max. and min.	TEMPERATURE: Mean Values Diff. from Normal	TEMPERATURE: Mean Wet Bulb	Relative Humidity	Mean Cloud Am'nt	PRECIPITATION: Am'nt	PRECIPITATION: Diff. from Normal	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Percentage of possible
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	0—10	mm.	mm.			
London, Kew Obsy.	1011·2	− 4·1	75	46	66·6	52·5	59·5	− 2·1	55·5	77	7·2	64	+ 7	21	4·7	33
Gibraltar	1015·3	− 1·4	91	64	81·2	68·4	74·8	− 1·2	67·5	70	3·6	2	− 1	2	...	...
Malta	1014·6	+ 0·2	96	67	84·3	73·0	78·7	+ 0·4	71·2	70	1·1	0	− 3	0	10·5	78
Sierra Leone	1014·3	+ 1·0	86	68	81·5	70·7	76·1	− 2·1	73·5	86	8·5	925	+ 23	28	...	...
Lagos, Nigeria	1012·1	− 1·5	87	71	83·2	74·3	78·7	+ 1·6	73·9	75	4·5	3	− 65	2	...	...
Kaduna, Nigeria	1016·9	+ 3·1	88	65	82·2	68·5	75·3	+ 1·4	70·2	89	1·1	442	+146	29	...	...
Zomba, Nyasaland	1017·4	+ 1·2	85	46	76·3	52·5	64·4	− 0·3	...	79	3·5	5	− 3	4	...	...
Salisbury, Rhodesia	1017·5	− 1·6	85	33	75·6	44·5	60·1	+ 0·2	49·9	49	0·9	0	− 2	0	...	...
Cape Town	1020·9	+ 0·7	77	38	63·2	47·4	55·3	+ 0·1	51·6	78	5·0	100	+ 13	10	...	...
Johannesburg	1022·2	0·0	75	28	63·3	42·0	52·7	− 1·2	41·0	55	1·6	4	− 5	2	9·8	88
Mauritius	1019·5	− 1·0	78	57	75·0	63·9	69·4	+ 0·9	64·6	78	6·7	109	+ 49	21	...	...
Bloemfontein	...	...	79	25	64·9	35·9	50·4	− 1·8	39·6	60	1·2	34	+ 22	2	...	...
Calcutta, Alipore Obsy.	1000·7	− 0·3	94	77	89·2	79·1	84·1	+ 1·1	79·7	89	9·1	385	+ 76	14*	...	...
Bombay	1004·6	− 1·1	89	75	85·4	78·4	81·9	+ 1·2	77·4	85	8·9	392	+ 32	14*	...	...
Madras	1004·6	− 0·9	102	76	95·3	78·9	87·1	+ 1·4	77·3	71	5·8	65	− 60	5*	...	...
Colombo, Ceylon	1008·9	0·0	87	73	85·6	77·3	81·5	0·0	77·4	74	8·2	115	+ 30	13	5·9	48
Hong Kong	1004·5	− 0·7	90	76	86·7	78·2	82·5	+ 0·4	77·6	82	6·7	271	− 94	16	7·3	57
Sandakan	...	...	91	73	88·5	75·0	81·7	− 0·2	76·7	78	...	169	− 36	13	...	...
Sydney	1018·9	+ 0·7	81	41	64·7	47·3	56·0	+ 1·0	50·3	67	4·0	58	− 20	11	6·5	60
Melbourne	1018·3	+ 0·2	70	35	58·5	44·1	51·3	+ 0·2	48·4	73	6·1	103	+ 57	14	4·3	40
Adelaide	1019·3	+ 0·1	75	39	63·9	46·3	55·1	+ 1·2	49·5	65	5·0	54	− 10	12	5·5	51
Perth, W. Australia	1019·1	+ 0·3	77	38	62·7	46·1	54·4	− 1·6	50·0	72	5·6	214	+ 71	16	5·5	50
Coolgardie	1018·3	− 1·0	82	33	66·5	41·3	53·9	+ 0·3	48·3	49	2·9	13	− 13	6	...	...
Brisbane	1019·8	+ 0·8	81	41	71·7	51·9	61·8	+ 1·2	57·6	68	4·1	34	− 22	12	7·2	65
Hobart, Tasmania	1013·6	0·0	64	36	56·6	41·7	49·1	+ 1·1	45·0	71	5·9	46	− 1	13	5·1	49
Wellington, N.Z.	1020·9	+ 6·2	61	31	55·0	44·8	49·9	+ 1·4	46·2	75	7·0	110	− 6	17	4·0	38
Suva, Fiji	1014·6	+ 0·3	...	65	...	69·7	...	...	70·7	84	7·6	688	+479	23	...	...
Apia, Samoa	1010·5	− 1·7	86	71	84·9	74·5	79·7	+ 2·5	76·8	87	5·6	136	+ 42	20	8·2	71
Kingston, Jamaica	1013·1	− 0·4	93	70	90·2	73·6	81·9	+ 0·4	75·4	72	5·7	90	− 3	8	...	...
Grenada, W.I.	1013·3	+ 0·7	88	70	85·3	75·3	80·3	+ 0·8	75·9	77	5·5	217	− 22	16	...	...
Toronto	1014·6	− 0·8	90	48	77·1	56·7	66·9	+ 0·3	61·1	75	4·2	100	+ 30	11	9·0	64
Winnipeg	1011·7	− 2·2	89	38	74·4	51·4	62·9	− 0·1	57·5	75	4·2	35	− 25	11	8·6	59
St. John, N.B.	1012·9	− 2·5	79	47	69·3	53·9	61·6	+ 1·0	57·4	84	6·4	170	+ 72	12	6·0	43
Victoria, B.C.	1016·9	− 0·3	71	46	64·8	50·9	57·9	− 2·2	53·7	80	4·0	13	− 4	2	9·2	64

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.

St. John, N.B.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Victoria, B.C.	1016·9	— 0·3	71	46	64·8	50·9	57·9	— 2·2	53·7	80	4·0	13	— 4	2	9·2	64

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.